ELECTROLESS PLATING OF NICKEL DIRECTLY ON ALUMINIUM ALLOYS

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Aluminium and its alloys can be plated with electroless nickel to increase hardness and reflectivity in certain electronic applictions. The well-known zincating pretreatment process is unsuitable in certain applications. A simple and effective pretreatment cycle has been developed for direct electroless nickel plating on various aluminium alloys for reducing strongly adherent and pore-free coatings. The phosphorous content in the coatings can be altered at will.

Increased applications are being found for plated aluminium and techniques for plating on aluminium are continuously being refined to make it a reliable method for utilizing light weight parts [1-3]. Various metals and alloys are plated over aluminium so as to increase the corrosion resisance, wear resistance, hardness, reflectivity etc. However, plating on aluminium is rendered very difficult owing to the tenacious natural oxide layer occuring on aluminium.

In recent days, application of electroless niickel on various metals are suggested to meet various specifications [4,5]. Electroless nickel is plated from both anodic and alkaline baths [6] to obtain bondable, brazable, solderable [7] coatings with high degree of lubricity in addition to hardness [8] and wear resistance[9]. Moreover, the coatings can be plated to offer better corrosion resistance [10]. Because of this combination of properties in a single layer, it has found many application in such diverse industries as petroleum[11], chemical, plastics, printing[12], zerox[13], aerospace, antenna parts, transistor bases, nuclear tools, textile, x-ray telescope[2] and food machinary as well as computer and optical hardwares. In the field of high frequency parts, aluminium is plated with electroless nickel followed by silver plating to impart a high degree of surface conductivity.

Various methods that are practiced to plate electroless nickel on aluminium can be broadly classified into four categories :

a) Cleaning-preplating-electroless nickel [14]

b) Cleaning-immersion nickel-electroless nickel [15]

c) Cleaning/etching-desmutting-activation-electroless nickel [15]

d) Cleaning-etching-double zincating-cyanide copper/brass strike-electroless nickel [16]

Though the double zincating cycle has been widely appreciated for plating on aluminium, it offers many difficulties and drawbacks thus requiring strict quality control and maintenance. Some of the zinc from the zincate layer dissolved into the electroless bath before nickel deposition begins. Even though some of this zinc may redeposit as an alloy with the nickel, after a while, zinc will contaminate the bath. The zinc film is extremely delicate. To complicate the matters, the viscous alkaline zincate solution is difficult to rinse from the work surface. If the zincating solution is not completely removed, subsequent plating will not adhere well. If the zincated surface is rinsed too long or too forcefully, it is easily damaged to the detriment of adhesion. Thus, there has been a real need for simple procedure to plate electroless nickel on aluminium. Other mentioned methods are specific to a particular alloy. Heat treatment is normally required for some of the methods to enhance adhesion. At the same time one has to keep in mind the variation of hardness of electroless nickel with duration and temperature at which is heat treated.

The authors report here the development of a symple procedure for plating electroless nickel on aluminium involving a lesser number of preplating and post plating steps.

EXPERIMENTAL

Aluminium panels of size 75 x 25 mm^2 were cut from 1 mm thick sheets of various alloys (2S-99.0% Al; 3S-1.2% Mn, rest Al;26S-4.25% Cu, rest Al and HE 15-4.25% Cu, 0.75% Si, 0.75% Mn, 0.5% Mg, rest Al). They were degreased with trichloroethylene. After proper polishing and buffing operations, rinsed, preconditioned in an etch-cum-desmutting solution, rinsed in running water and distilled water. The composition of etch cum desmutting solution, was arrived at after an elaborate study with various etchants and pretreating cycles. The panels were activited and were immediately transferred to the electroless nickel solution of the following composition[17].

Nickel sulphate	..	25 g/l
Sodium pyrophosphate	..	50 g/l
Sodium hypophosphite	..	25 g/l
Ammonia	..	22 m/l
pH	..	10-11
Temperature	..	60-65°C

After an intial strike deposition in the above solution, the plates were given a thick electroless nickel. Depending on the desired phosporous content in the final deposite, this plating is done in either the above electrolyte or room temperature electrolyte [18] in an acidic electrolyte of the following composition

Nickel sulphate	..	23 g/l
Sodium hypophosphite	..	24 g/l
Lactic acid	..	27 g/l
Sodium succinate	..	20 g/l
pH	..	4.7
Temperature	..	90-95°C

All the chemicals used were of laboratory reagent grade. Distilled water was used for solution preparation. The panels after deposition were rinsed, dried and subjected to standard procedures for porosity and adhesion tests. Aluminon and caustic porosity tests were adopted for examining the porosity. Tests for adhesion included 1) peel off test using an adhesive tape, 2) bend test, 3) baking test, 4) the grinding test and 5) the drill test.

All the tests are qualitative in nature and indicate whether the adhesion is good or not.

RESULTS AND DISCUSSION

Selection of suitable cycle of operation determines the adhesion, composition and corrosion resistance of the deposit. Moreover, improper surface pretreatment can also affect the operation and life of the electroless nickel bath by causing spontaneous bath decomposition, bath shut off and step plating of the work pieces.

Cleaning Step

Various cleaning and etching solutions like 50 g/l sodium hydroxide; 50 g/l sodium hydroxide + 30 g/l sodium gluconate; 25% v/v nitric acid + 1-5% v/v hydrofluoric acid; 2.5 g/l ammonium bifluoride + 20 g/l sodium carbonate; 20 g/l sodium carbonate + 25 g/l trisodium phosphate were tried. Only the last solution gave strongly adherent deposits. Hence for further studies, an etching solution containing 25 g/l trisodium phosphate and 20 g/l sodium carbonate was used at 60°C for 2 minutes.

Desmulting Step

These cleaners leave the surface with a 'smut' film which can be removed normally by immersion in a nitric acid solution 10-20% v/v at room temperature. However, it is unsuitable for aluminium alloys containing copper. Combination of acids such as hydrofluoric/nitric acid were tried and the last combination was very effective in improving the adhesion of the deposit. A mixture of 10% v/v sulphuric acid, 5% v/v hydrofluoric acid and 25% v/v nitric acid, operating at room temperature for 2 minutes was chosen as optimum concentration.

Activation Step

This activation step avoids skip plating. Various activating solutions were evaluated, among them an amine solution containing hypophosphite was most effective. Though ammonia could be used in place of triethanolamine, evaporation of ammonia causes undesirable defects in the panels. Concentration of sodium hypophosphite is also critical; concentration more than 50 g/l leads to rapid reduction of nickel while solutions below 10 g/l does not initiate the reduction. Hence, a solution containing 25 g/l sodium hypophosphite and 20 ml/l of triethanolamine was chosen as the optimum and activation carried out for 30-60 seconds.

Electroless Plating Step

The specimen after activation step was transferred to the electroless bath without rinsing, after draining the excess solution from the panel. The temperature of the electroless nickel solution has to be maintained between 60°-65°C since the rate of deposition at low temperature is poor. At higher temperatures ($>$ 65°C) violent reaction occurs leading to deposition of greyish powder over the panel and in the plating tank. The strike bath is unaffected by the triethanolamine carried over from the activating solution. Continuous addition of ammonia should be made to maintain the pH in view of the evaporation of ammonia at high temperature.

After an initial strike, further thickness can be built up either in acid or alkaline electroless baths which normally produce proper coating with high or low phosphorous contents respectively. Any standard baths [19] other than the above suggested solution can also be used for the same.

Coating Properties

The panels were tested and were found to have low porosity and good adhesion. The low porosity offers better corrosion resistance in comparision to electroplated nickel over aluminium. Deposits obtained from acid electrolytes were rich in phosphorous content (8-15%) and are more corrosion resistant than deposits from alkaline baths which are low in phosphorous content (2-8%). High phosphorous content improves the ductility of the deposit. However they do have less hardness. Hence, the choice of the electroless nickel system should be based on the application of the deposit.

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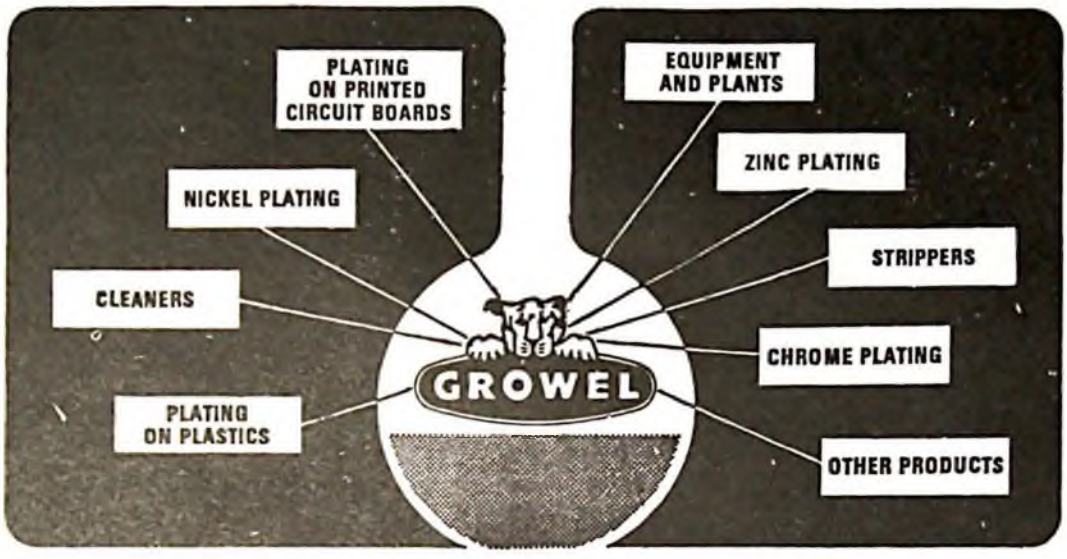
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